Naval Medical Research Institute

Bethesda, MD 20889-5607

NMRI 93-15 April 1993

AN ANALYSIS OF PHYSICALLY DEMANDING TASKS PERFORMED BY U.S. NAVY FLEET DIVERS

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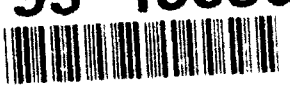

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TECHNICAL REVIEW AND APPROVAL
NMRI 93-15

The experiments reported herein were conducted according to the principles set forth in the current edition of the "Guide for the Care and Use of Laboratory Animals," Institute of Laboratory Animal Resources, National Research Council.

This technical report has been reviewed by the NMRI scientific and public affairs staff and is approved for publication. It is releasable to the National Technical Information Service where it will be available to the general public, including foreign nations.

ROBERT G. WALTER
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Commanding Officer
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UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCL	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NMRI 93-15	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Naval Medical Research Institute 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Bureau of Medicine and Surgery
6c. ADDRESS (City, State, and ZIP Code) 8901 Wisconsin Avenue Bethesda, MD 20889-5055	7b. ADDRESS (City, State, and ZIP Code) Department of the Navy Washington, DC 20372-5120
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Naval Medical Research & Development Command 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) 8901 Wisconsin Avenue Bethesda, MD 20889-5044	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 63713N; PROJECT NO. M0099; TASK NO. .01A; WORK UNIT ACCESSION NO. 1003

11. TITLE (Include Security Classification)

(U) AN ANALYSIS OF PHYSICALLY DEMANDING TASKS PERFORMED BY U.S. NAVY FLEET DIVERS

12. PERSONAL AUTHOR(S)
E.J. Marcinik, B.A. Schibly, D. Hyde, and T.J. Doubt

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Technical Report	FROM 12/91 TO 02/93	1993 April	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	physical fitness; diver selection; job performance; occupational requirements

19. ASSTRACT (Continue on reverse if necessary and identify by block number)

In an effort to better align the physical capabilities of U.S. Navy fleet divers with occupational physical requirements, the objectives of this research investigation were to:

(1) Develop a general taxonomy of physically demanding tasks performed by fleet divers.

(2) Identify a subset of job tasks representative of diver's work.

(3) Develop a job performance test battery based on representative fleet diver tasks.

Seventy-two fleet divers reported a total of 110 physically demanding tasks using a job analysis survey. The relative distribution of these tasks according to basic body effort is presented below:

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION	
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL Regina E. Hunt, Command Editor	22b. TELEPHONE (Include Area Code) (202) 295-0198	22c. OFFICE SYMBOL SD/RSD/NMRI

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

BASIC BODY EFFORT	PERCENT OF TOTAL
Single lift without carry	19.1%
Lift repetitively without carry	20.0%
Lift and carry	21.8%
Carry while running/swimming	16.4%
Pushing/pulling	20.0%
Other	2.7%

Eighteen representative job tasks were identified by divers during group interview sessions. Development of the following job performance test battery was based on objective work-site measurements and an extensive review of survey, interview, and videotape data:

(1) Diver lifts 100 lb descent line clump off the deck to a height of 2 ft.

(2) Diver lifts/carries twin 80 SCUBA bottles a distance of 150 ft (including up/down ship's ladder). Repeated 3 times.

(3) SCUBA diver (wearing twin 80s, breathing air) swims a distance of 50 ft while carrying a 24 lb tool bag. Repeated 4 times.

(4) SCUBA diver (wearing twin 80s) attempts to remain on the surface by fin kicking for a period of 5 min.

(5) Topside diver pulls an umbilical line (weighted to 100 lb) a distance of 50 ft.

(6) MK-21 diver (fully weighted, single SCUBA, breathing air) descends/ascends a 14 ft vertical ladder.

Performance on these tests will serve as the basis for developing minimum entry/graduation level, physical screening standards for fleet diver training based on specific job performance requirements.

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ACKNOWLEDGEMENTS

The authors wish to thank the Commanding Officer and the staff of the Naval Diving Salvage and Training Center, Panama City, FL for their assistance in conducting this research investigation.

This word was supported by Naval Medical Research and Development Command Work Unit No. 63713N M0099.01A-1003. The opinions expressed in this paper are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U. S. Government.

I. INTRODUCTION

Although work performed by fleet divers has often been characterized as being physically demanding, the Navy does not presently have systematic procedures for selecting and training divers based on job requirements. The development of job-related selection and training methods will lead to substantial cost savings for the Navy through enhanced screening, productivity, and reduction of injuries and time lost off the job.

According to the Naval Diving and Salvage Training Center (NDSTC), approximately $1.2 million dollars in training funds was lost from FY-89 to FY-91 due to students failing to meet entry level diver physical screening test requirements.

To better align diver physical capabilities with job requirements, the Chief of Naval Operations tasked the Naval Medical Research Institute (NMRI) to develop job-related physical training standards and programs for the Fleet Diving Program (CNO OP-23 ltr).

To accomplish this tasking, an analysis was undertaken to identify the physically demanding jobs performed by fleet divers. The purpose of the present investigation was to:

(1) Develop a general taxonomy of physically demanding job tasks performed by fleet divers.

(2) Identify a subset of tasks representative of diver's work.

(3) Develop a job performance test battery based on representative fleet diver tasks.

Development of tests to measure physically demanding task performance will serve as the foundation for the creation of job-related physical training standards and programs for the Fleet Diving Program.

II. METHODS

The research design was as follows:

(1) A job task analysis survey was administered to identify physically demanding tasks performed by fleet divers.

(2) Group interviews with divers were conducted to identify a subset of tasks representative of the physical strength and endurance demands of diver's work.

(3) Representative tasks were videotaped and analyzed in order to select tasks for job performance test construction.

(4) Selected tasks were objectively measured to develop specific procedures for job performance assessment.

Subjects

Seventy-two male fleet divers participated in the study. These divers were briefed on the nature of the study, attendant risks and benefits, and gave voluntary consent to participate in the study. This study was approved by NMRI's Committee for the Protection of Human Subjects.

Divers completed a survey and were interviewed in groups regarding the physically demanding job tasks they were routinely required to perform. Divers represented the following commands:

Naval Diving Salvage and Training Center, Panama City, FL

Mobile Diving and Salvage Unit Two, Little Creek, VA

Shore Intermediate Maintenance Activity, Little Creek, VA

U.S. Grapple (ARS-59), Little Creek, VA

U.S. Yellowstone (AD-41), Little Creek, VA

Second Class Dive School, Coronado, CA

Consolidated Diving Unit, San Diego, CA

Survey

The job task analysis survey, Appendix A, was based on a survey developed by Robertson and Trent (1986) to determine the physical demands of common shipboard tasks. The survey requested that divers provide examples of physically demanding tasks they routinely performed according to the following basic body efforts:

* Single lift without carrying
* Lift repetitively without carrying
* Lift and carry
* Carry while running/swimming
* Pushing/pulling
* Other

Divers were also asked to provide an estimate of the weight (lb) and distance (ft) an object was moved, and the time (min/sec) required to complete the task.

Interviews

After completing the survey, divers were interviewed in groups. The purpose of these interviews was to select the most representative tasks for each basic body effort. Interview information also provided significant insight into the level of skill involved in task performance and the degree of individual versus team participation. These factors served as criteria in the development of job performance tests.

Videotape Analysis

Representative tasks were videotaped at NDSTC. Approximately 2 h of filming was conducted. Dry land tasks were filmed onboard ship and at various training sites at NDSTC. Underwater tasks were filmed during training evolutions in the swimming pool, wet pot, and in open water.

Visual analysis of the representative tasks was conducted to identify major muscle group involvement and level of skill required to perform the task. The analysis also assisted to establish specific job performance test procedures.

Representative Task Selection

Selection of representative tasks for job performance test development was based on an extensive analysis of survey, interview, and videotape data. The following task criteria were established to assist in this endeavor.

(1) Task is frequently performed.

Rationale: Everyday work activities were considered to be more representative of work performed by fleet divers than equally physically demanding tasks performed only on an occasional basis.

(2) Task requires a minimal level of skill.

Rationale: Tasks were selected that required primarily physical and not technical skills. Selected tasks such as lifting a descent line clump and lifting/carrying SCUBA bottles involved basic movements and required little skill. A task such as bolting a flange overhead while fin kicking was not selected because of the degree of skill involved. It involved complex movements using tools and required more than one movement at the same time.

(3) Task is primarily an individual and not a team effort.

Rationale: Single person tasks were selected because performance on such tasks could be more accurately measured. Assessing an individual's contribution to a team task was found to be very difficult in most cases.

(4) Task is feasible to administer (i.e., safe, minimal equipment, minimal staff testing requirements, etc.).

Rationale: Tasks which would increase the risk of injury, beyond that experienced during regular training evolutions, were not considered. Due to time and manpower restraints anticipated at NDSTC, tasks requiring an inordinate amount of time or staff to administer were not selected.

(5) Tasks involve different basic body efforts.

Rationale: Tasks were chosen to represent each of the basic body efforts involved in diver's work. This ensured that the functional capability of all major muscle groups used by divers would be assessed. Selection of more than

one task for the same basic body effort was considered redundant (e.g.,lift/carry SCUBA bottles and lift/carry dive bag).

Job Performance Test Construction

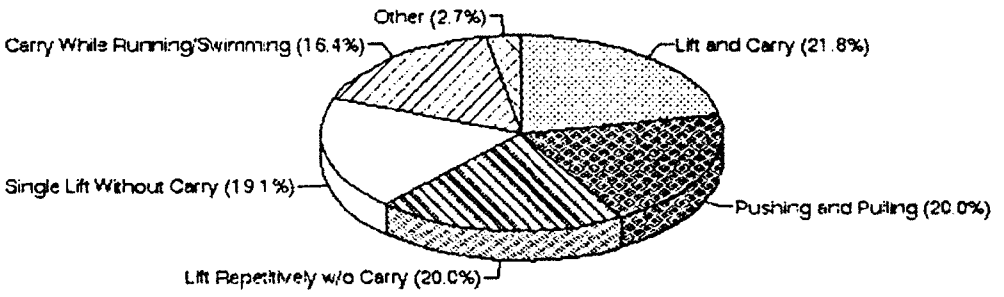
Job performance test scenarios are based on general task criteria reported by divers (Appendices B-F). To establish specific test procedures, objective measurements were taken at NDSTC. Weights of objects lifted/carried were determined using a calibrated scale. Distances that objects moved were recorded with a measuring tape. Task performance times were recorded with a stopwatch.

III. RESULTS

Survey Data

Results of tne task analysis survey are listed in Figure 1. Fleet divers reported a total of 110 physically demanding tasks they were required to perform. There was a fairly even distribution of tasks among the five basic body efforts. The majority of these tasks involved the handling of materials, tools, and equipment. Task criteria (i.e., weight lifted, distance carried, and performance time) reported by the divers are listed in Appendices B-F.

Figure 1-Relative Distribution of Job Tasks Performed by Navy Fleet Divers



Interview Data

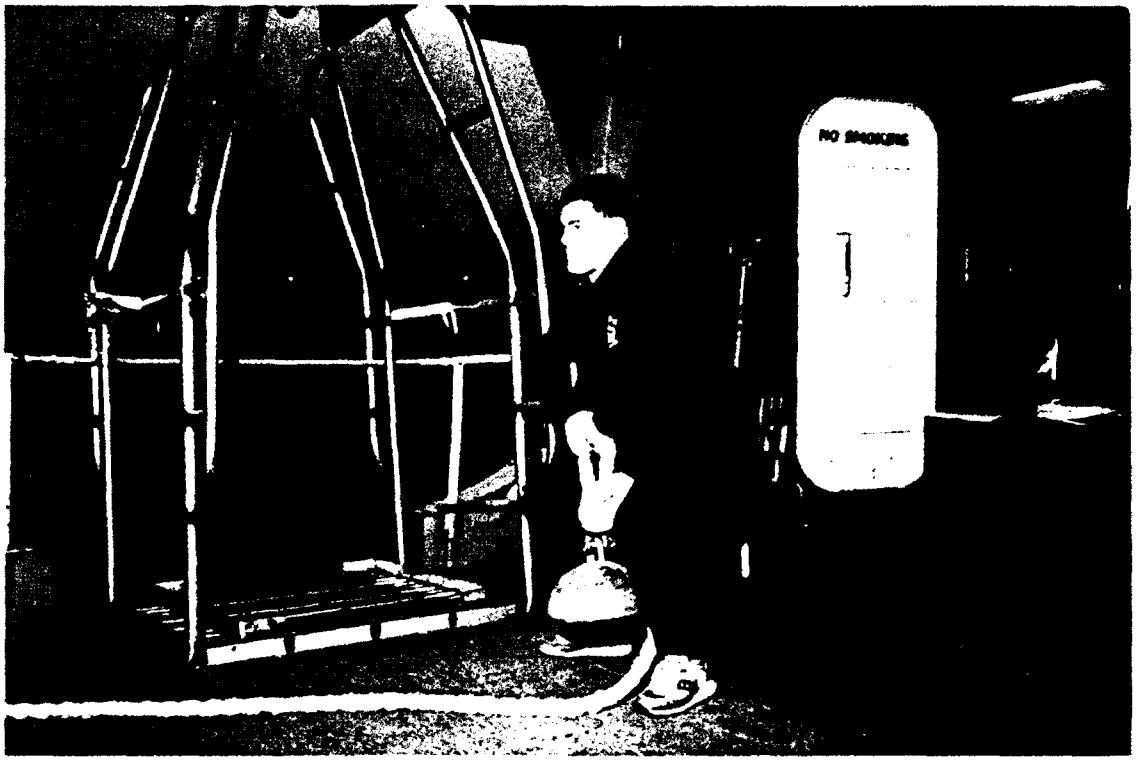
Interview sessions with groups of divers helped to reduce the number of representative tasks. Based on a group consensus of diver interviewed, 18 tasks were selected as most representative of the work performed by fleet divers (Table 1).

Table 1: Representative Job Tasks Selected by Fleet Divers	
BASIC BODY EFFORT	OBJECT
Single lift without carry	1. Descent line clump 2. Cofferdam 3. SCUBA bottle 4. Umbilical
Lift repetitively without carrying	5. SCUBA bottle 6. Diving equipment 7. Dive bag
Lift and carry	8. SCUBA bottle 9. Patch 10. Umbilical
Carry while running/swimming	11. Tools 12. Patch 13. Tool bag
Pushing/pulling	14. Umbilical 15. Chainfall
Other	16. Climbing ladder 17. Walking on the bottom 18. Fin kicking

Representative Task Selection and Job Performance Test Development

The representative tasks listed below were selected for job performance test construction. Videotape analysis was useful in identifying major muscle groups involved in performing the tasks and designing basic test scenarios. Preliminary testing at NDSTC was conducted to refine test procedures and determine test criteria (i.e., weights lifted, distances and times).

FIGURE 2. Diver lifts descent line clump.



Procedures: Diver will be required to lift a descent line clump off the deck to a height of 2 ft.

Weight: 100 lb clump

Time: No requirement

Basic Body Effort: Single lift without carry

Major Muscle Groups Involved: Hand/forearm flexors, biceps, deltoids, quadriceps, lower back.

Skill Level: Low

Test site: NDSTC training craft

FIGURE 3. Diver lifts/carries twin 80 SCUBA bottles.

Procedures: Diver will be required to lift the twin 80 SCUBA bottles from the pier and carry them on the training craft, down an inclined ladder, and set them down in a dive locker (total distance of 75 ft). Diver will then lift the bottles and carry them up the ladder to the starting point. Task will be repeated 3 times.

Weight: 83 lb

Distance: 450 ft

Estimated Time: 6.5 min

Basic Body Effort: Lift and carry

Major Muscle Groups: Hand/forearm flexors, biceps, deltoids, quadriceps, gluteals, calves, abdominals, lower back.

Test Site: NDSTC training craft

FIGURE 4. SCUBA diver swims/carries tool bag.

Procedures: SCUBA diver (wearing twin 80s, breathing air) will be required to swim across the pool (distance of 50 ft) carrying a tool bag (24 lb). Task will be repeated 4 times.

Weight: 24 lb tool bag

Distance: 200 ft

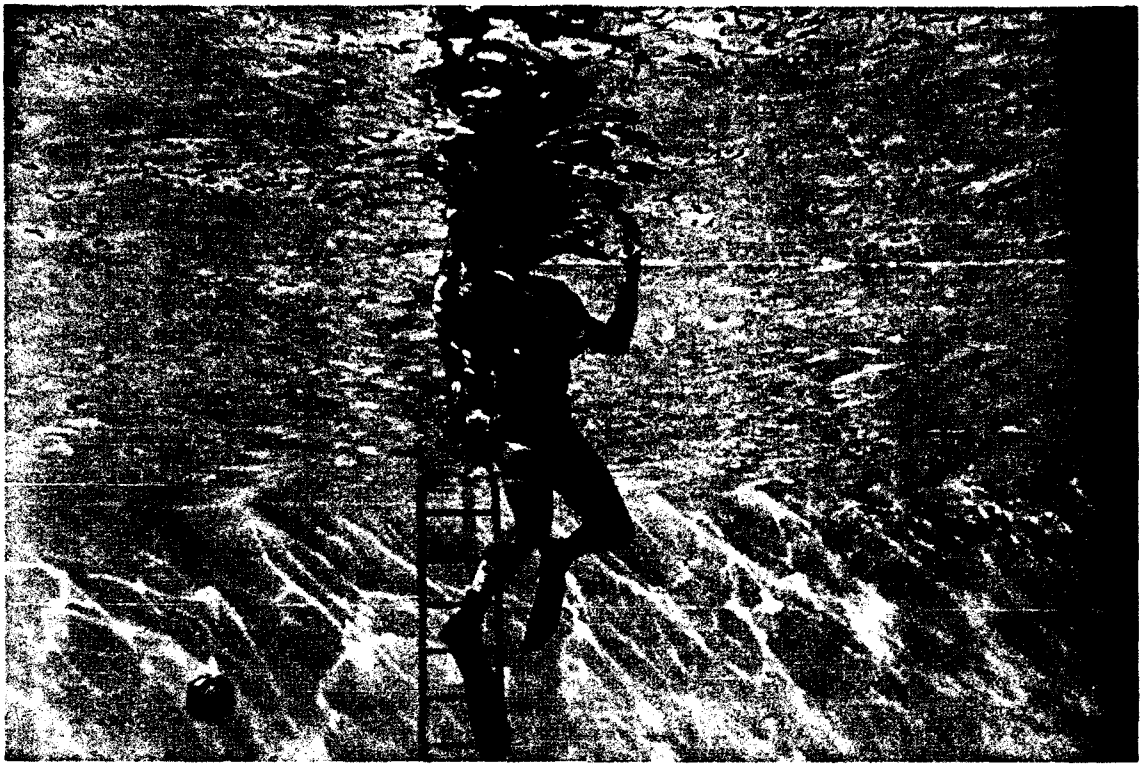
Estimated Time: 5.0 min

Basic Body Effort: Carry while swimming

Major Muscle Groups: Hand/forearm flexors, biceps, triceps, deltoids, quadriceps, hamstrings.

Test Site: NDSTC Pool

FIGURE 5. SCUBA diver attempts to remain on surface by fin kicking.



Procedures: Diver in SCUBA (wearing twin 80s) attempts to remain on the surface by fin kicking for a period of 5 min.

Weight: 83 lb SCUBA bottles

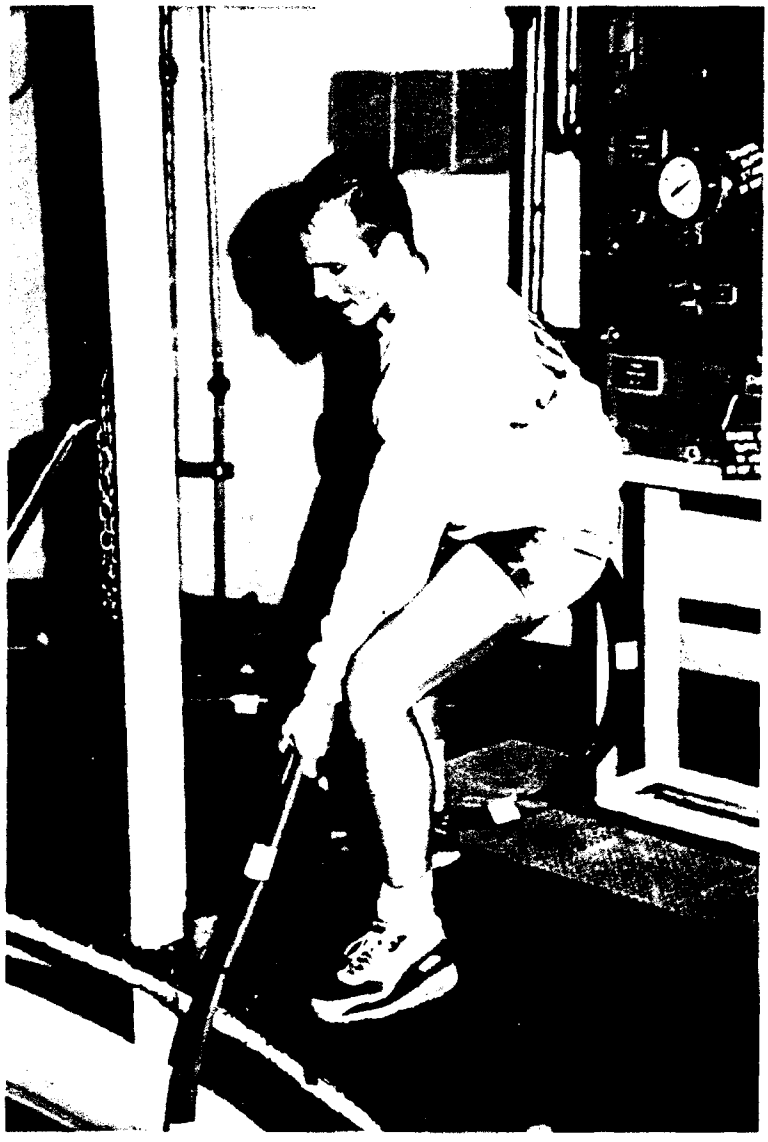
Time: 5 min

Basic Body Effort: Fin kicking

Muscle Groups Involved: Quadriceps, hamstrings

Test Site: NDSTC Pool

FIGURE 6. Topside diver pulls a weighted umbilical line.



Procedures: Topside diver will be required to pull a submerged umbilical line (weighted to 100 lb) to the deck (distance of 50 ft).

Weight: 100 lb

Distance: 50 ft

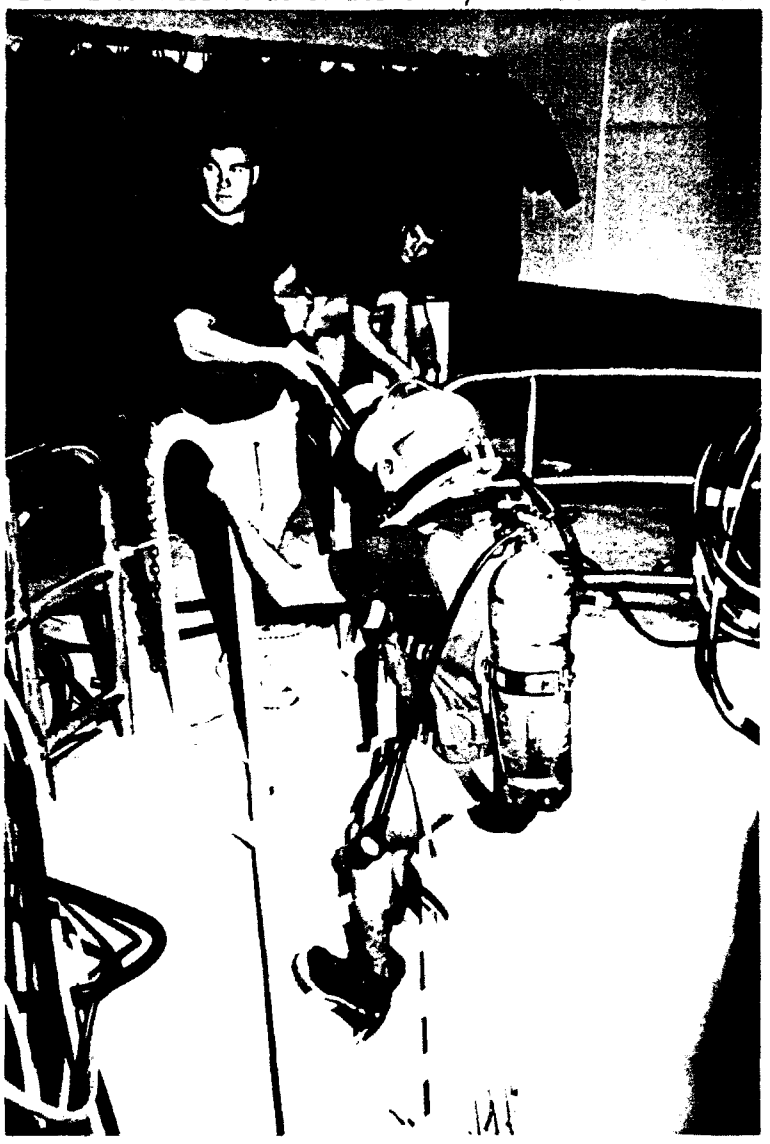
Estimated Time: 1 min

Basic Body Effort: Pulling

Major Muscle Groups: Latissimus dorsi, biceps, deltoids, hand/forearm flexors

Test Site: Ascent Tower

FIGURE 7. MK-21 diver descends/ascends vertical ladder.



Procedures: MK-21 diver (fully weighted, single SCUBA, breathing air) will be required to descend/ascend a 14 ft vertical ladder.

Distance: 14 ft

Estimated Time: 1.5 min

Basic Body Effort: Climbing

Major Muscle Groups Involved: Quadriceps, gluteals, calves, hand/forearm flexors

Test Site: NDSTC Open Tank

IV. DISCUSSION

The task analysis survey proved to be an efficient means of documenting a wide array of physically demanding fleet diving tasks. Survey results indicated a fairly even distribution of tasks according to basic body effort (Fig. 1). This finding underscores the need for a fleet diver physical training program that does not focus on enhancing one particular component of fitness, but rather emphasizes a total body fitness approach. Doubt and Mecocci (1985) have proposed such a fitness program for U.S. Navy saturation divers.

Divers reported the muscular strength demands of their work are considerable. The majority of strength demanding tasks involved the handling of tools, equipment, or materials. The estimated weight of objects lifted during a single effort ranged from 20 to 500 lb (Appendix B). However, many of these lifting tasks were team efforts. Lifting loads for individual divers rarely exceed 100 lb. During interview sessions, divers emphasized the need for upper/lower torso and back strength when performing heavy lifts.

Compared to single-lift tasks, the estimated weight of objects lifted repetitively was substantially lower, with a range of 5 to 150 lb (Appendix C). Divers reported these tasks could extend for periods up to 2 h in duration. The requirement to perform multiple-lift tasks (i.e., lifting SCUBA bottles, flanges, etc.) illustrates the need for muscular endurance, in addition to muscular strength, to perform effectively as a fleet diver.

Divers reported most aerobically demanding job tasks were performed in the water. These included tasks such as fin kicking for extended periods of time while conducting salvage work and swimming with tools and equipment to and from the job site. Divers stressed the importance of being aerobically fit and believed the cardiovascular benefits derived from running translated into improved in-water work performance. It is interesting to note that while running is an integral component of the current NDSTC physical training curriculum, none of the tasks reported by divers involved running.

In total, divers reported performing 110 job-related tasks. It would be impractical to measure a diver's performance on each one of these tasks. Many tasks involved the same basic body effort and varied only in the type of material or equipment handled. It was decided that the most efficient approach to assess job performance was to select tasks according to basic body effort category.

Lifting a descent line clump was selected to represent the basic body effort of single lift without carry. The 100 lb lift requirement approximates the maximum load usually placed upon a single diver. Handling SCUBA bottles was reported by divers for all basic body efforts. To streamline the testing process, a single test was designed which involved lifting bottles and carrying them up/down a ladder. Choosing representative in-water tasks was largely guided by the test selection criteria. For example, working on ballast tank grates is an integral part of ship's husbandry. However, this task may take hours to complete and cannot be measured in a training school setting where time is at a premium. This task is also a team effort which makes individual diver performance difficult to measure.

Based on the information gathered during interview sessions, it was decided that in-water work could most accurately be assessed by measuring basic swimming and fin kicking performance. The swim test required divers to swim a short distance while carrying a tool bag. This test was thought to be more related to ship's husbandry work than a lengthy open water swim. The fin kicking test was similar to the test administered to diver candidates at NDSTC, except the time requirement was extended from 1 to 5 min.

Pulling an umbilical line was selected because of the critical nature of pulling a stricken diver to the surface. The distance the line was pulled was reduced to 50 ft (diver's estimated 140 ft, Appendix C) to reduce the risk of back injuries incurred during testing. Descending/ascending a vertical ladder in MK-21 was selected to represent the basic effort of climbing. It was thought this test would be more feasible to conduct than measuring a diver's ability to walk on the ocean bottom. Divers performed this task in MK-21, since MK-21 is rapidly replacing MK-5 in the fleet.

While this investigation has helped to characterize the physical nature of diver's work, the actual relationship between job performance and the physical fitness of divers is not known. To date, several research investigations have demonstrated a relationship between muscularly demanding shipboard task performance and measures of physical fitness. Robertson and Trent (1985) found that two measures of isometric strength (1 arm-pull and 2 arm-lift) were significant predictors of physically demanding shipboard damage control evolutions (e.g., stretcher carry, P-250 pump carry, fire hose handling, etc.). Marcinik, Hodgdon, Englund, and O'Brien (1987), using a sample of U.S. Navy

male recruits, found significant correlations between performance of physically demanding shipboard tasks and tests of muscular strength. Multiple regression analysis revealed arm curl and leg press strength scores to be significant predictors of task performance. Beckett and Hodgdon (1987), found that Navy Physical Readiness Test scores (i.e., 1.5 mile run/walk time and push-up performance) and lean body mass can be used to predict performance of generic lift and carry tasks.

The next phase of this research project will be to measure the extent to which the current NDSTC physical screening test predicts job performance unique to divers. Since the current screening test (1.5 mile run, 500 yard swim, pull-ups, sit-ups, and push-ups) does not include measures of upper/lower torso one-repetition maximum strength or body composition; tests to measure these dimensions of fitness will also be included in the assessment. Results of this research will validate the current physical screening test and other fitness measures for job performance prediction purposes.

Future efforts will focus on quantifying energy expenditures of physically demanding shipboard and in-water tasks. Findings will assist to establish minimum job-related aerobic requirements for fleet divers.

V. CONCLUSIONS

1. Using a task analytic approach, the physically demanding work performed by U. S. Navy fleet divers has been categorized.
2. A diver job performance test battery has been developed based on objective work-site measurements and an extensive analysis of survey, interview, and videotape data.

3. Performance on this test battery will provide the basis for establishing improved physical selection criteria for the U.S. Navy Fleet Diving Program.

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APPENDIX A - Diver Task Analysis Survey

PLEASE PRINT

DESCRIBE THE SINGLE MOST PHYSICALLY DEMANDING EFFORTS NAVY DIVERS ARE REQUIRED TO PERFORM DURING PREPARATION, DIVER TENDER, AND DIVER TASKS.

SINGLE LIFT WITHOUT CARRY **(Example: Lift and stack sets of scuba jugs)**

1._____
_____
_____

a. What is the estimated weight (lb) of the object lifted? _____

b. What is the estimated distance (ft) the object is lifted? _____

LIFT REPETITIVELY WITHOUT CARRYING **(Example: Lift several tools from deck to overhead position)**

1._____
_____
_____

a. What is the estimated weight (lb) of the object lifted? _____

b. What is the estimated distance (ft) the object is lifted? _____

c. What is the estimated time (min/sec) required to perform the task? _____

LIFT AND CARRY **(Example: Lift and carry scuba bottles)**

1._____
_____
_____

a. What is the estimated weight (lb) of the object lifted? _____

b. What is the estimated distance (ft) the object is carried? _____

c. What is the estimated time (min/sec) required to perform the task? _____

CARRY WHILE RUNNING/SWIMMING **(Example: Carry tool kit from stage to job site)**

1. _____
_____
_____

a. What is the estimated weight (lb) of the object carried? _____

b. What is the estimated distance (ft) the object is carried? _____

c. What is the estimated time (min/sec) required to perform the task? _____

PUSHING/PULLING **(Example: Position crane hook and load during salvage operation)**

1. _____
_____
_____

a. What is the estimated weight (lb) of the object pushed/pulled? _____

b. What is the estimated distance (ft) the object is pushed/pulled? _____

c. What is the estimated time (min/sec) required to perform the task? _____

OTHER

1. _____
_____
_____

a. What is the estimated weight (lb) of the object moved? _____

b. What is the estimated distance (ft) the object is moved? _____

c. What is the estimated time (min/sec) required to perform the task? _____

APPENDIX B - Physically Demanding Tasks Reported by Fleet Divers
(Single Lift Without Carry)

	Weight (lb)		Distance (ft)	
Object	(I)	(M)	(I)	(M)
1. Ballast Tank Grate	100	100	3	3
2. Camel Bumper	30	30	5-10	7.5
3. Carpenter Stop*	350 200 275	275	50 3-5 -	27
4. Chainfall	40-50	45	100	100
5. Cofferdam*	100 50-150 150	117	3 - 6	4.5
6. Compressor*	80-100 80-100	90	2-5 10-50	16.7
7. Descent Line Clump*	150 100-125 100 100 100 100	109	2-3 3 3 3 3 - 5	3.2
8. Dewatering Gear	250-300	275	300	300
9. Ducts	70	70	5	5
10. Flanges	120	120	3-4	3.5

Object	Weight (lb) (I)	Weight (lb) (M)	Distance (ft) (I)	Distance (ft) (M)
11. K Bottles	150	150	1-8	4.5
12. Injured Diver*	150-220 175	180	3 4	3.5
13. Medical Kit	150	150	3	3
14. Patches*	100 85-100 100 40 25-100 20-80 100 70 60-150 75 60-100	79.0	2 5 4 5 5 5-6 - 10 10 6 10	6.3
15. Outboard Motor*	175 150	162.5	3-4 5	4.2
16. Oxygen Bottles	80	80	1-1.5	1.2
17. Rope Guard	75	75	60	60

Object	Weight (lb) (I)	Weight (lb) (M)	Distance (ft) (I)	Distance (ft) (M)
18. SCUBA Bottles*	50-85	72	5	7.4
	70		3-5	
	70		5	
	70		15	
	80		-	
	70		-	
	50		15	
	50		20	
	70		10	
	70		10	
	80		3-4	
	60-100		2	
	60-100		-	
	80		3-4	
	80		4	
	80		4	
	80		3	
19. Sound Head	50-60	55	1.5	1.5
20. Umbilical*	400-500	243.7	3-4	5.4
	300		3	
	100-150		5	
	100		10	
21. Wire Rope	300	300	2-4	3

(I) Individual estimates
(M) Mean estimates
* Task reported by more than one diver.

APPENDIX C - Physically Demanding Tasks Reported by Fleet Divers
(Lift Repetitively Without Carry)

Object	Weight (lb) (I)	Weight (lb) (M)	Distance (ft) (I)	Distance (ft) (M)	Time (min) (I)	Time (min) (M)
1. Ballast Tank Grates	100	100	5	5	30	30
2. Boat Slings	65	65	3	3	2	2
3. Chainfalls*	60 25-40 40	44	3 - 6-7	4.7	- 20 5-10	13.7
4. Communications Box	70	70	5	5	1	1
5. Descent Line Clump	150 100	125	5-10 2-4	5.3	1-1.5 1-10	3.4
6. Diving Equipment	50-85 42 75 42 70 10-70 10-25 10	45.5	5 4-5 6-8 1-5 2-6 20 5-10 5	7	5-15 1 - <1 30 30 10 1	11.8
7. Dive Bags*	40-50 60 25-40	44	4-6 2-5 2-5	4	10 10-15 -	11.2
8. Flanges*	25-75 10-20	32.5	25-50 10	23.7	5-25	8.5 2

Object	Weight (lb) (I)	Weight (lb) (M)	Distance (ft) (I)	Distance (ft) (M)	Time (min) (I)	Time (min) (M)
9. Grip Hoist	20	20	-		1	1
10. Hatches	30	30	5	5	3	3
11. Helium/Oxygen Bottles*	125 100	113.5	5 3	4	- <30	30
12. Hoses	100	100	11	11	30	30
13. K Bottles	80	80	6	6	15	15
14. MK-21	20	20	4	4	<1	1
15. Patches*	80 50 75-80 10-15	55	20 6 4-5 2-5	8.5	<1 10 2 5-10	5
16. Powerhead	80	80	20	20	<1	1
17. SCUBA Bottles*	85 80 100 85 60-100 60-100 70 70 70 70 70 50	76	5-9 2-4 4-5 10 3-4 4-5 10 10 10 5 5 15	7.3	- 30 <1 5 3-4 1-2 <1 <1 <1 3 10 15	6.5
18. T Plates	5	5	10	10	20	20

Object	Weight (lb)		Distance (ft)		Time (min)	
	(I)	(M)	(I)	(M)	(I)	(M)
19. Tools	20-40	30	2-3	2.5	60-120	90
20. Tool Bag	50	50	3	3	10	10
21. Zincs*	25-50 25 30-50	34	1-2 3 3	2.5	1-3 2 5	4.5

(I) Individual estimates
(M) Mean estimates
* Task reported by more than one diver

APPENDIX D - Physically Demanding Tasks Reported by Fleet Divers
(Lift and Carry)

Object	Weight (lb)		Distance (ft)		Time (min)	
	(I)	(M)	(I)	(M)	(I)	(M)
1. Anchor	70	70	-	-	3	3
2. Beach Gear	20-80	50	20-50	35	-	
3. Chainfalls	75	75	30	30	10	10
4. Descent Line Clump	100	100	30	30	1	1
5. Diver	200	200	200	200	2	2
6. Dive Equipment*	60 20 100	90	150 20-30 300-600	208	5 <1 10	8
7. Dive Bags*	100-150 40 40	68	- 130 150-300	177	- 15 -	15
8. Ducts	50	50	90	90	-	
9. Flange	50	50	1800	1800	4	4
10. Fuel Can	45	45	150	150	4	4
11. 5 Gallon Cans	45	45	40	40	5	5
12. Helium/Oxygen Bottles*	80 125	103 -	- 5	5	- -	- -

Object	Weight (lb) (I)	Weight (lb) (M)	Distance (ft) (I)	Distance (ft) (M)	Time (min) (I)	Time (min) (M)
13. Hoses*	40 150	95	200 40	120	5 15	10
14. K Bottles	-	-	300	300	3-5	4
15. Medical Kits	150	150	300	300	-	-
16. Outboard Motors	100-175	137	30-100	65	10	10
17. Patches*	100 50-100 75 5-150 10-60	73	50 - 300 5-20 100-200	128	- - 5 3 3-5	4
18. Salvage Gear	60-100	80	30-40	35	-	-
19. SCUBA Bottles*	50-85 60 35-65 70 70 50 50 70 50 40 70 70 60-100 60-100 85 80 80	65	50-100 200-300 - 150-200 100-300 35 40 - 30-40 150 100 100 10 10-20 150 150 100 100	105	1 25 <1 - - <1 15 5 1.5 2.5 2 30 <1 2-5 5 3 4 1	6.2

Object	Weight (lb) (I)	Weight (lb) (M)	Distance (ft) (I)	Distance (ft) (M)	Time (min) (I)	Time (min) (M)
20. Sound Head	65-70	67	450	450	3-5	4
21. Tool Boxes	80	80	300	300	15	15
22. Umbilical*	100-200 200 100 150	150	150-600 600 300 1300	644	<1 5 5 5	4
23. Wire Rope	70-80	75	750	750	6-8	7
24. Wire Strap	20-40	30	60-120	90	-	-

(I) Individual estimates
(M) Mean estimates
* Task reported by more than one diver

APPENDIX E - Physically Demanding Tasks Reported by Fleet Divers
(Carry While Running/Swimming)

Object	Weight (lb) (I)	Weight (lb) (M)	Distance (ft) (I)	Distance (ft) (M)	Time (min) (I)	Time (min) (M)
1. Aircraft Wreckage	50-250	150	50	50	-	-
2. Anchor	50-100	75	10	10	5-10	7.5
3. Backing Plate	40	40	150	150	2	2
4. Camera	10	10	10-200	105	2-30	16
5. Chainfalls*	35-55 50-70	53 -	25 50-70	43 -	1-2 2	1.7
6. Cofferdam*	125 150 100-150	133	10-100 30-40 50-100	55	5-60 3-120 <1	32
7. Charleston Gear	50-250	150	-	-	-	-
8. Flanges*	30 40-60 20-30 5-50 20-50 50 120 20	45	50 25-30 30 10-60 20-30 15 2 300	61	1-5 <1 <1 2-5 <1 15 30-60 5	9.2

Object	Weight (lb) (I)	Weight (lb) (M)	Distance (ft) (I)	Distance (ft) (M)	Time (min) (I)	Time (min) (M)
9. Patches*	-	50	50-75	53	30	11
	50		20		30	
	40		60		5	
	30-50		100		10	
	75		100		5	
	50		50		5	
	30		10		35-50	
	10		40-50		2-3	
	75		150		2-4	
	40-50		20		20	
	50		100		15	
	40		50		3	
	75		50		3	
	100		60		15	
	50		25-30		1-30	
	40		50		3	
	50-100		40		5-10	
	10-50		30		< 1	
	30-100		25		10	
	10-15		15		2	
10. Press	100	100	40	40	1	1
11. SCUBA Bottle	60-100	80	50	50	20-30	25
12. Shackles	5-60	32.5	10-60	35	1-3	2
13. Stricken Diver*	200	200	-	50	1-5	4
	200		50	50	4-6	4
14. Swim Fins	3	3	300	300	1	1

Object	Weight (lb) (I)	Weight (lb) (M)	Distance (ft) (I)	Distance (ft) (M)	Time (min) (I)	Time (min) (M)
15. Tools*	30-40	40	40	226	30-60	19
	50-75		-		-	
	7		30-50		-	
	20-30		25		30	
	50		50-200		-	
	25-200		300		2-15	
	1-10		1000		5-7	
	1-50		50		3	
16. Tool Bag*	10-35	47	40	185	< 1	4.6
	40-70		100		3	
	50-70		200		5.5	
	50		400		9	
17. Wire Pennant	-	-	60-150	105	15-20	17.5
18. Zincs	25	25	10-100	55	2	2

(I) Individual estimates
(M) Mean estimates
* Task reported by more than one diver

APPENDIX F - Physically Demanding Tasks Reported by Divers
(Pushing/Pulling/Other)

	Weight (lb)		Distance (ft)		Time (min)	
Object	(I)	(M)	(I)	(M)	(I)	(M)
1. Ballast Tank*	100	100	30	8	10	13
Grates	100		3		15-30	
	100		2		-	
	100		4		<1	
	100		4		-	
	100		4		20	
2. Beach Gear*	250	212	5-10	11	-	5
	100-250		10-20		5	
3. Boss Nut	400	400	30-50	40	5-10	7.5
4. Breaker Bars*	100-200	100	-	2	15-25	70
	50		2		120	
5. Cable	30	30	100-150	125	3-10	6.5
6. Chainfalls*	60	101	2	6	-	6
	100		5		1	
	200		5		<1	
	100		15		10-20	
	30-60		1-5		5-10	
7. Coffer Dam*	300-350	325	10-15	19	3-45	31
	50-70		20-30		20-30	
8. Descent Line	50-100	87.5	30-160	103	4	4.5
Clump*	100		30-190		5	
9. Flanges*	30	90	3	2	3-5	6
	150		1		5-10	

Object	Weight (lb) (I)	Weight (lb) (M)	Distance (ft) (I)	Distance (ft) (M)	Time (min) (I)	Time (min) (M)
10. Grip Hoist	200	200	5	5	5	5
11. Hydraulic Wrench	40-60	50	25-30	27.5	<1	1
12. MK-12 Diver*	- 200-250 200 250 300-350 300 290	265	10-200 250 200 50-100 190 180 110	160	5-30 30-60 - <1 3 3 15	14
13. Patches*	80 30-100 100 50 75 50-100 100 80	78	40 1-5 40 100 50 75 50 20	47	4 1-5 10 2 10 20 10-15 10	9
14. Pilgrim Nut	50-200	125	2-3	2.5	15-30	23
15. Powerhead	75-100	87	50	50	<1	<1
16. Pumps*	350-1000 - 200	437	- 30 10	20	- <1 5	3
17. Salvage Gear*	75 -	75	10 10-50	20	30 5-20	21
18. SCUBA Bottles	80	80	4-5	4.5	<1	<1
19. Stricken Diver	150-200	175	2-3	2.5	<1	<1

Object	Weight (lb) (I)	Weight (lb) (M)	Distance (ft) (I)	Distance (ft) (M)	Time (min) (I)	Time (min) (M)
20. Tow Hook	50	50	100	100	20-30	25
21. Umbilical*	100 150 100 125 100	115	150 100 150 100 200	140	3 2 1.5 1.5 5	2.6
22. Wire Rope*	100 10-20 100-200	88	4-5 20-100 75	47	- 60 30	45
OTHER:						
1. Climb Vertical* Ladder	200 225 200	208	10 15 12	12	1 1.5 <1	1.2
2. Torque Bolts	-	-	-	-	30	30
3. Tread water* (Fin kicking)	-	-	-	-	2 1 3 2	2
4. Walk on bottom	-	-	50	50	3	3

(I) Individual estimates
(M) Mean estimates
* Task reported by more than one diver